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Methodological issues
Issues relating to greenhouse gas inventories

Estimation of fugitive emissions from fuels

Note by the secretariat*

Summary

Fugitive emissions from fuels are an important source of greenhouse gases (primarily methane (CH_4) and to a lesser extent carbon dioxide (CO_2) and nitrous oxide (N_2O)) for a number of Parties included in Annex I to the Convention. The *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* (1996 IPCC Guidelines), as elaborated by the *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* (IPCC good practice guidance), contain methodologies that are being used by many Parties to estimate fugitive emissions from fuels. These methodologies range from tier 1 methods using default emission factors to rigorous country-specific methods using country-specific emission factors. Although the 1996 IPCC Guidelines and the IPCC good practice guidance have proved to be useful tools for the estimation of fugitive emissions from fuels, some areas for further improvement have been identified. This document contains suggestions that could be considered by the IPCC in its work on the development of the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* and by Parties in the preparation of national greenhouse gas inventories.

* This note was prepared by the secretariat on the basis of input provided by Mr. David Picard.

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I. Introduction

A. Mandate

1. The Subsidiary Body for Scientific and Technological Advice (SBSTA), at its seventeenth session, invited the Intergovernmental Panel on Climate Change (IPCC) to revise the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* (1996 IPCC Guidelines) taking into consideration the relevant work under the Convention and the Kyoto Protocol, and to aim to complete the work by early 2006.[1] In response, the IPCC initiated this work in 2003 and agreed on the terms of reference, table of contents and work programme for the development of the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (2006 IPCC Guidelines).

2. The SBSTA, at its nineteenth session, considered the initial information on methodological issues relating to the preparation of national greenhouse gas (GHG) inventories by Parties, contained in document FCCC/SBSTA/2003/INF.10, and decided to forward it to the IPCC for consideration. It also requested the secretariat to continue to cooperate with the IPCC and provide more detailed information based on the latest available GHG inventory submissions by Parties and the results of the technical review of GHG inventories. Such information could serve as input to the planned IPCC meetings that will take place during the development of the 2006 IPCC Guidelines.[2]

B. Scope of the note

3. This note addresses methodological issues relating to the estimation of fugitive emissions from fuels.[3] It provides brief descriptions of the methodological information that was submitted by Parties included in Annex I to the Convention (Annex I Parties) in their 2003 GHG inventory submissions, of information on the methodologies included in the 1996 IPCC Guidelines and the IPCC *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* (IPCC good practice guidance), and of other methodological information that is available for the estimation of fugitive emissions from fuels.

C. Possible action by the Subsidiary Body for Scientific and Technological Advice

4. The SBSTA is invited to consider the information in this note and forward it to the IPCC for its consideration. Parties may wish to consider the information in this note when preparing their national GHG inventories.

II. Background

5. Fugitive emissions from fuels are an important source of greenhouse gases (primarily methane (CH_4) and to a lesser extent carbon dioxide (CO_2) and nitrous oxide (N_2O)). Emissions of CH_4 from this sector often account for a large portion of a Party's total national CH_4 emissions.

6. The 1996 IPCC Guidelines and the IPCC good practice guidance provide methodologies and advice to GHG inventory experts on how to estimate fugitive emissions from all fuels (solid, liquid and gaseous). According to the 1996 IPCC Guidelines, emissions of CH_4 can be estimated from data on the amount and type of fuel produced, transported and processed.

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[1] FCCC/SBSTA/2002/13, paragraph 14 (f).
[2] FCCC/SBSTA/2003/15, paragraphs 17 (a) and (c).
[3] Methodological information on other sectors is provided in document FCCC/SBSTA/2004/INF.3 which deals with emissions from road transport, and FCCC/SBSTA/2004/INF.4, which deals with agriculture.

III. Solid fuels

A. General

7. Fugitive emissions from solid fuels are generated primarily by coal mining and handling activities, but may also include contributions from a variety of other sources including the transformation of coal to coke, burning coal mines, abandoned mines, and the gathering and handling of other solid fuels such as peat. Most of the fugitive emissions from coal mining and handling are attributed to the release of natural gas from the coal seam (coal-bed CH_4 with trace amounts of heavier hydrocarbons, CO_2 and sometimes hydrogen sulphide (H_2S)) as the mine is being worked. The amount of gas present in a coal seam tends to increase with the depth of the mine. Degassing wells are sometimes drilled to help remove free gas from the coal seam before mining. If the gas is conserved by a gathering system, any associated fugitive emissions are estimated and reported under natural gas systems (see chapter IV). If the gas is simply vented or flared, these emissions are attributed to coal mining. Coal-bed CH_4 may also be released by mine dewatering wells.

8. After coal has been mined, some residual natural gas remains trapped in the interstitial pores and physically adsorbed on its external and internal surfaces. This residual gas is slowly released over time, with larger releases potentially occurring each time the coal is agitated (e.g., loaded or unloaded), during crushing and cleaning and, where applicable, when it is finally pulverized.

B. Intergovernmental Panel on Climate Change methodologies

9. The 1996 IPCC Guidelines and the IPCC good practice guidance present methodologies for estimating CH_4 emissions from coal-related activities such as mining and post-mining handling and processing. For each activity different emission factors are used depending on whether the coal is from an underground or a surface mine. Three different methodological tiers are provided:

(a) Tier 1: application of default emission factors to the amount of coal produced or handled

(b) Tier 2: application of country-specific emission factors to the amount of coal produced or handled

(c) Tier 3: use of emission-measurement results for individual mines.

10. Generally, the higher the methodological tier, the greater the required assessment effort and the resulting accuracy of the estimate of emissions. However, the actual level of accuracy achieved in each case will depend on the completeness and quality of the input data and parameters used, including emission factors.

C. Information reported by Annex I Parties

1. Methods and emission factors used

11. Table 1 summarizes the methodologies and emission factors used by each Annex I Party in estimating its fugitive emissions from solid fuels, and the types of GHGs considered in each subcategory. These data are taken from section 1.B.1 of the common reporting format (CRF) completed by each Party for 2001, the most current year available at the time of this note. The information on methodologies and emission factors was taken from section “Summary3s1” of the CRF. For some Annex I Parties the information provided in either the CRF or the national inventory reports (NIR) was not sufficient to reproduce the individual emission estimates or understand all of the applied assumptions.

Table 1. Information reported by Annex I Parties on methods and emission factors used in 2001 for estimating fugitive emissions from solid fuels

	Method used			Emission factors used		
Party	**CO_2**	**CH_4**	**N_2O**	**CO_2**	**CH_4**	**N_2O**
Australia	NE	T2	NE	NA	CS	NE
Austria		C			CS	
Bulgaria	NE	T1	NE	NE	D	NE
Canada	CS	CS	CS	CS	CS	CS
Croatia		T1			D	
Czech Republic	D	T3		D	CS	
Denmark	NO	D	NO	NO	D	NO
Finland	CS	CS	NA	CS	CS	NA
France	C	C	C	CS	CS	CS
Germany	NO	CS	NO	NO	CS	NO
Greece		T1			D	
Hungary		D			CS	
Ireland	NA	NA	NA	NA	NA	NA
Italy		D,C			D,CS	
Japan		T2			CS	
Latvia	NO	NO	NO	NO	NO	NO
Luxembourg	NA	NA	NA	NA	NA	NA
Netherlands	IE	IE	IE			
New Zealand		T1			CS,D	
Norway	T1	T1		T1	D	
Poland		CS			CS	
Portugal	MB	C,T2			C	
Romania	NE	T1	NE	NE	T1	NE
Slovakia	NA	T1	NO	NA	CS	NO
Spain	CS,C	T1		PS,C	CS	
Sweden	CS	CS	CS	CS	CS	CS
Switzerland	NO	NO	NO	NO	NO	NO
United Kingdom	T2,T3	T2	T2	CS	CS	C
United States	NA	T2,T3	NA	NA	CS	NA

C: CORINAIR, CS: country specific, D: IPCC default, NE: not estimated, IE: included elsewhere, NA: not applicable, NO: not occurring, PS: plant specific, T1: IPCC tier 1 methodology, T2: IPCC tier 2 methodology, T3: IPCC tier 3 methodology.

12. The subcategories for fugitive emissions from solid fuels are mining and post-mining activities at both underground and above-ground mines, solid fuel transformation and other. More information for these subcategories is given below.

2. Coal mining and post-mining activities

13. All Parties with coal mining activities reported emissions of CH_4 for this subcategory. Only Norway reported estimates for CO_2 emissions. Some raw (or formation) CO_2 will naturally occur in association with the CH_4 emissions, but the IPCC good practice guidance indicates that this amount is negligible and may be neglected for simplification purposes. If the effluent from degassing wells is flared or ventilation exhaust from underground mines is treated by catalytic oxidation, CO_2 emissions will be more extensive and should then be quantified.

14. No Party with coal mining and post-mining activities reported any N_2O emissions. N_2O emissions would occur wherever coal-bed CH_4 is disposed of by thermal oxidation (e.g., flaring of the effluent from degassing wells), but they are likely to be negligible.

3. Solid fuel transformation

15. Six Annex I Parties (France, Germany, Italy, Spain, Sweden and the United Kingdom) provided estimates of fugitive emissions from solid fuel transformation. The first three reported CH_4 emissions for this category and the other three reported predominantly CO_2 emissions with either no or small amounts of CH_4.

16. Five Parties (Australia, Austria, Czech Republic, Netherlands and the United States) estimated either CH_4 or CO_2 emissions from this subcategory, but reported these emissions under other IPCC subcategories. Six Parties (Bulgaria, Canada, Japan, Latvia, New Zealand and Romania) did not estimate emissions for either gas, indicating that some solid fuel transformation occurs but that the amount of associated fugitive emissions had not been evaluated.

17. No Party reported fugitive N_2O emissions from solid fuel transformation activities. Such activities normally involve oxygen-deficient processes, and so would not be expected to contribute N_2O emissions, except where there is associated waste-gas flaring or incinerations and even then the amounts would be small.

4. Other

18. Five Parties (Czech Republic, Denmark, Finland, France and Germany) provided estimates of emissions from solid fuels under the subcategory "Other." Specific sources for these emissions included SO_2 scrubbing, preparation of soils for peat production, post-mining activities and abandoned mines. The contributions by the Czech Republic and Finland were either all or virtually all CO_2, whereas the contributions by the other Parties were reported as all CH_4. No Parties reported any N_2O emissions under this subcategory.

D. Consideration of the Intergovernmental Panel on Climate Change methodologies

1. Tier 1 methodology

19. The tier 1 approach for solid fuels allows a Party to select an appropriate emission factor from a range of values. Different factors are applied for mining and post-mining activities, and for coal from underground mines and surface mines. Although this approach is simple and easy to apply, the problem is that the emission factors effectively become static values that do not reflect real changes in emission intensities (e.g., due to aging of mines and the application of specific control measures). Thus, the reported changes in emissions between years simply reflect the changes in coal production, and shifts between underground and surface mining.

20. Table 2 provides a comparison of an independent calculation of the maximum and minimum tier 1 emissions for coal with actual values reported by selected Annex I Parties for 2000. The calculated values were developed using 2000 coal production, import, export and apparent consumption statistics published by the Energy Information Administration (EIA) (www.eia.doe.gov/pub/international/ieapdf/t05_05.pdf).

21. The selected coal statistics were converted from a gross heating value basis to a mass basis for use in the tier 1 emission calculations. In performing these conversions, the heating value term was adjusted to force agreement with the coal production reported by each Party in section 1.B.1 of the CRF. In each case, the post-mining emission factors were applied to the Party's apparent consumption. For those Parties that reported domestic coal production (section 1.B.1 of the CRF), the split between underground and surface mined coal was assumed to be the same as that reported. For those Parties that reported emissions estimates but no activity data in the CRF, it was assumed that all coal came from underground mines (a conservative approximation in terms of the emissions level).

Table 2. Fugitive CH_4 emissions from coal for 2000 reported by selected Annex I Parties and independently calculated tier 1 values

	Data reported by Annex I Parties for 2000			Independent tier 1 calculation	
Party	**Method used**	**Emission factor used**	**Reported emissions (Gg)**	**Min emissions (Gg)**	**Max emissions (Gg)**
Austria	C	CS	0.01	NA	NA
Belgium	C	C	0.62	0.07	2.64
Canada	CS	CS	45.19	28.77	140.46
Czech Republic	T3	CS	239.00	162.99	219.48
Denmark	D	D	3.32	0.00	1.05
Estonia			11.25	0.22	1.00
Finland	CS	CS	1.00	0.00	0.91
France	C	CS	122.10	29.96	96.95
Greece	T1	D	54.30	3.32	24.59
Hungary	D	D	77.17	67.82	108.19
Italy	D,C	D,CS	3.05	12.83	57.27
Latvia			NO	0.00	0.01
Luxembourg			0.00	0.00	0.03
Netherlands	IE		NO	0.00	1.94
New Zealand	T1	CS/D	25.58	6.99	20.56
Norway	T1	D	0.34	4.21	10.73
Poland	CS	CS	566.55	538.86	1 158.65
Portugal			NO	0.00	0.98
Slovakia	T1	CS	25.54	58.52	60.31
Spain	T1	CS	57.57	119.12	356.44
Sweden	CS	CS	NO	0.00	0.57
United Kingdom	T2	CS	264.99	198.69	285.53
United States	T2,T3	CS	2 903.10	2 824.30	5 311.25

C: CORINAIR, CS: country specific, D: IPCC default, IE: included elsewhere, NA: not applicable,
NO: not occurring, T1: IPCC tier 1 methodology, T2: IPCC tier 2 methodology, T3: IPCC tier 3 methodology.

22. Table 2 shows that fugitive CH_4 emissions from coal reported by most Annex I Parties are within or just outside the calculated tier 1 range. Where Parties have applied a tier 2 or tier 3 approach, this finding verifies the reasonableness of the tier 1 default emission factors. For some countries in table 2 there are big differences between the reported and calculated values (e.g. Estonia, France, Greece, Italy, Norway, Slovakia, Spain). Although insufficient information was generally available to resolve these differences, they appear to be due to a combination of different emission factors and activity levels.

23. Use of a country-specific or higher tier approach may not necessarily lead to higher estimates than use of tier 1 approach. Thus, it is not unreasonable that some countries report emission estimates closer to the minimum value even though they use a tier 2 or even a tier 3 (country-specific) method. In general, country-specific and higher tier approaches may be expected to give more accurate results than a tier 1 approach as they would be expected to use more reliable emission factors and to better account for country-specific circumstances (e.g., local CH_4 content of coal and applied control measures).

2. Tier 2 methodology

24. By using country-specific emission factors developed from measurement campaigns, a Party is often able to develop more accurate estimates of its fugitive emissions from solid fuels. However, changes in emission intensities may only be captured each time these factors are updated. Depending on how frequently measurements are performed, such updates may result in apparent discontinuities in the time series, which would need to be explained in detail. Between updates of the emission factors, the tier 2 approach, although more accurate, has the same limitations as the tier 1 approach.

3. Tier 3 methodology

25. The use of mine-specific emissions monitoring data potentially offers the most accurate and reliable means of tracking real changes in emissions and emission intensities. However, this methodology requires the use of detailed or disaggregated activity data and additional emission factors. Usually, much greater cost and effort is required to collect and utilize this information. As in the case of lower tiers, the accuracy of the final emission estimates will depend on the quality of the applied activity data and emission factors. If the quality of the input data is generally comparable to, or better than, that of the lower tiers, then the fact that the analysis is being done at a more disaggregated level will result in a more accurate final emission estimate. If the required activity data or emission factors are of lesser quality, it is possible that the tier 3 approach would actually result in a less accurate final result.

4. Activity data

26. For tier 1 and tier 2, the statistics on solid fuels that are needed are national data on primary fuels (including hard coal and lignite) and on derived fuels (including patent fuel, coke oven coke, gas coke, brown coal/peat briquettes, coke oven gas and blast furnace gas). Typically, the statistics that are available at the national level summarize total coal consumption, production, reserves, trade, and average heat content and also provide breakdowns by type of coal produced (i.e., anthracite, bituminous or lignite). At the international level the published statistics (e.g. from the International Energy Agency (IEA)) do not provide information on the method of mining (i.e., surface/strip or underground) or depth of mines although these data are usually collected and sometimes available on special request.

27. In the absence of any information on the type of mining, a conservative first approximation is to assume that all lignite coal is surface mined and all bituminous and anthracite coal is produced from underground mines. However, such an assumption could lead to overstating of emissions, because substantial amounts of bituminous coal and lesser amounts of anthracite coal are also produced from surface mining operations. The 1996 IPCC Guidelines and the IPCC good practice guidance do not provide guidance for national GHG inventory experts on how to handle international statistical information to ensure that emissions from this subsector are estimated accurately.

IV. Oil and natural gas

A. General

28. Fugitive emissions from oil and natural gas systems comprise all non-fuel-combustion emissions – emissions due to equipment leaks, venting and flaring, evaporation losses (e.g., from storage tanks, loading/unloading activities, surface impoundments, land farms, and exposed oil sands deposits) and accidental releases (pipeline dig-ins, well blowouts, spills, etc.). Gas removed from the process for on-site or field uses is notionally referred to, and reported as, fuel gas. However, some of this gas may be used for purposes other than fuel combustion, such as blanket gas, flare and vent header purge gas, instrument supply gas, enriching of acid gas[4] streams to allow stable flaring, blowcase gas, and compressor start gas. Care is needed to properly account for these other uses and avoid inclusion of such fuel use in the fuel combustion category.

29. Although CH_4 is the predominant type of fugitive GHG emission in the oil and gas sector, noteworthy fugitive emissions of CO_2 and, to a much lesser extent, N_2O, may also occur. CO_2 is present as a natural constituent of most untreated hydrocarbon streams and occurs in high concentrations in some enhanced oil recovery schemes (e.g., where CO_2 and fireflood schemes are used). Consequently, it is a constituent of all vented and leaked natural gas or associated gas volumes. Appreciable amounts of raw

[4] Acid gas: gas that contains hydrogen sulphide (H_2S), total reduced sulphur compounds, and/or CO_2 that is separated in the treating of solution gas or non-associated gas.

CO_2 are stripped from the produced gas at sour-gas processing and ethane extraction plants, and are subsequently discharged to the atmosphere through vents or flare systems. Furthermore, hydrogen production plants at petroleum refineries and upgraders also contribute to fugitive CO_2 emissions, where these emissions are a waste by-product of the production of hydrogen.

30. The specific amount of fugitive emissions tends to decrease in moving downstream through a given oil or gas system. This reflects the generally decreasing amounts of equipment and processing activity, as well as the increasing operating reliability and emphasis on fugitive emissions control (i.e., due to increasing product value), in progressing through these systems. On natural gas systems a noticeable reduction in fugitive emissions usually occurs for the portions of the system in odorized service. For oil systems, most of the CH_4 and raw CO_2 is removed or lost during the early stages of production, which greatly reduces the potential for fugitive GHGs from the transportation and downstream storage portions of the system. At refineries, fugitive emissions may be attributed primarily to leaks from equipment in gas or vapour service, biogenic gas formation from tailings or waste-water treatment ponds and land farm operations, CO_2 emissions from hydrogen plants and sour-water strippers, and limited venting and flaring. There should be no potential for fugitive CH_4 or CO_2 emissions associated with the handling and storage of refined products except where product vapours are flared.

31. The key factors that affect the amount of fugitive emissions from a given operation are the amount and type of infrastructure employed, the integrity of the system, the amount of waste gas created and the incentives or requirements to control waste-gas volumes and reduce fugitive emissions. These factors, in turn, are a function of the following parameters and may vary greatly between countries, regions and even individual companies (as applicable):

(a) Design and operating practices

(b) Frequency of maintenance and inspection activities

(c) Type, age, and quality of equipment

(d) Type of hydrocarbons being produced or handled and their composition

(e) Throughputs and operating conditions

(f) Pumping or compression requirements

(g) Metering requirements

(h) Treatment and processing requirements

(i) Frequency and duration of process upsets

(j) Sweet, sour or odorized service

(k) Population density near the facility

(l) Offshore or onshore operation

(m) Distance to market or the next downstream segment of the industry

(n) Market value of waste hydrocarbons

(o) Applicable environmental and conservation regulations

(p) Pricing/economic incentives (e.g., if the cost of lost gas is passed on to the customer there is no incentive for gas companies to reduce CH_4 losses).

32. Regulations and pricing/economic incentives are usually the most important factors affecting the amount of fugitive emissions from venting and flaring. Emissions from equipment leaks are proportional to the amount of process infrastructure and are a general reflection of the quality of the equipment components, and inspection and maintenance programmes. Typically, the amount of emissions from equipment leaks is lowest where the process fluid is highly toxic (e.g., contains H_2S) or has been odorized.

B. Intergovernmental Panel on Climate Change methodologies

33. The 1996 IPCC Guidelines and the IPCC good practice guidance provide three methodological tiers for estimating fugitive emissions from oil and natural gas systems:

(a) Tier 1: a top-down method in which average production-based emission factors are applied to reported oil and gas production volumes

(b) Tier 2: a mass balance approach primarily intended for application to oil systems where the majority of the associated gas[5] and solution gas[6] production is vented or flared

(c) Tier 3: a rigorous assessment of emissions from individual sources using a bottom-up approach.

C. Information reported by Annex I Parties

1. Methods and emission factors used

34. Table 3 summarizes the methods and emission factors used by Annex I Parties in estimating their 2001 fugitive emissions from oil and natural gas for CO_2, CH_4 and N_2O. This information was taken from section “Summary3s1” of the CRF, and the emission estimates were taken from section 1.B.2 of the CRF.

35. Most Parties used a combination of approaches, mainly tier 1, CORINAIR or country-specific methods. The United Kingdom was the only Party to report the use of a tier 3 approach in assessing all its fugitive emissions from oil and natural gas. The Czech Republic reported a combination of tier 1 and 3 approaches in evaluating its CH_4 emissions and did not evaluate its fugitive CO_2 or N_2O emissions from oil and natural gas. The only Parties to report the use of a tier 2 approach were Australia (for all three gases), Portugal (for CH_4) and the United States (for CO_2).

36. The subcategories for fugitive emissions for oil and natural gas are: oil, natural gas, venting, flaring and other. The oil and gas subcategories are further disaggregated by industry segment, and the venting and flaring subcategories are disaggregated into oil, gas and combined. More information on these subcategories is given below.

2. Oil systems

37. Typically, all Annex I Parties with oil exploration, production, transport or refining/storage activities reported CH_4 emissions. The only exception was Japan, which reported CO_2 emissions from exploration but no CH_4 emissions in that category. Fewer than half the Parties that reported CH_4 emissions for an oil activity also reported CO_2 emissions for the same category.

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[5] Associated gas: gas that is produced from an oil or bitumen pool. This may apply to gas produced from a gas cap or in conjunction with oil or bitumen.

[6] Solution gas: gas that is in solution with produced oil or bitumen.

Table 3. Information reported by Annex I Parties on methods and emission factors used in 2001 for estimating fugitive emissions from oil and natural gas

	Method used			Emission factors used		
Party	**CO_2**	**CH_4**	**N_2O**	**CO_2**	**CH_4**	**N_2O**
Australia	T2	T2	T2	CS	CS	CS
Austria	C,CS	C	C	CS,PS	CS	CS
Bulgaria	NE	T1	NE	NE	D	NE
Canada	CS	CS	CS	CS	CS	CS
Croatia	CS	T1		CS	D	
Czech Republic	NE	T1,T3		NE	D,CS	
Denmark	C	C	C	C	C	C
Finland	CS	CS	NA	PS	PS	NA
France	C	C	C	CS	CS	CS
Germany	NE	CS	NE	NE	CS	NE
Greece		C			C	
Hungary		T1			M,CS	
Ireland	T1	T1	NA	CS	CS	NA
Italy	C,CS	C,CS		CS	CS	
Japan	T1	T1		D	D	
Latvia	NE	CS	NE	NE	PS	NE
Luxembourg	C	C	C	C	C	C
Netherlands	CS,T3	CS,T1	CS,T1	CS	CS	CS
New Zealand	T1	T1		CS,D	CS,D	
Norway	CS	CS	CS	CS	CS	CS
Poland		CS			CS	
Portugal	MB	C,T2			C	
Romania	NE	T1	NE	T1	NE	NE
Slovakia	NA	D	NO	NA	D,CS	NO
Spain		CS,C			PS,C	
Sweden	CS	CS	CS	CS	CS	CS
Switzerland	C	C	C	CS	CS	CS
United Kingdom	T3	T3	T3	CS	CS	CS
United States	T2	M	NA	CS	M,CS	NA

C: CORINAIR, CS: country specific, D: IPCC default, NE: not estimated, IE: included elsewhere, M: model, MB: mass balance, NA: not applicable, NO: not occurring, PS: plant specific, T1: IPCC tier 1 methodology, T2: IPCC tier 2 methodology, T3: IPCC tier 3 methodology.

38. Four Parties (Belarus, Croatia, Norway and Portugal) reported fugitive emissions due to the distribution of refined products. The first two reported CH_4 emissions only and although the reported amounts were small (less than 1 Gg CH_4 or 21 Gg CO_2 equivalent), they represented more than one third of each of these Parties' total reported CH_4 emissions from oil activities. The other two Parties reported CO_2 emissions only, with these contributions each amounting to just more than 21 Gg CO_2. Austria and Sweden estimated emissions for CH_4 and NO_2 in this category but reported these emissions under other IPCC subcategories.

39. Two Parties (Australia and the United Kingdom) included flaring under oil activities in section 1.B.2.a of the CRF rather than breaking it out and reporting it in section 1.B.2.c. The N_2O emissions reported by Australia were the only instance of N_2O emissions being accounted for under oil activities, and only occurred under the exploration and refining/storage subcategories.

3. Natural gas systems

40. All Annex I Parties with natural gas activity either provided estimates of CH_4 emissions or reported these emissions under another IPCC subcategory. Most of these Parties also reported fugitive CO_2 emissions, mostly under the production/processing category. Switzerland also reported N_2O emissions under natural gas activities: a small amount attributed to natural gas transmission. Germany provided separate estimates of fugitive emissions from exploration activities for natural gas, whereas other Parties with natural gas production reported under other IPCC subcategories (Canada, Japan, United Kingdom and United States).

41. Some additional observations, based on reported data from some Annex I Parties and which may need further consideration, are listed below:

(a) Vented and flared volumes are reported under the natural gas category (section 1.B.2.b of the CRF) rather than under the vented and flared categories (section 1.B.2.c of the CRF)

(b) CO_2 emissions from flaring are reported, but not N_2O emissions

(c) Fugitive emissions for natural gas transmission are reported, but not emissions due to natural gas distribution or leakage at industrial or commercial and residential end-users

(d) Fugitive emissions due to other leakage at commercial and residential end-users are reported, but not emissions from gas transmission or distribution which would also have to occur for the natural gas to be available

(e) Emissions from gas distribution are reported, but not from gas transmission.

4. Venting and flaring

42. Some Annex I Parties with oil and gas activities did not report emissions from venting or flaring. The Annex I Parties that reported venting in section 1.B.2.c of the CRF typically reported either only CH_4 emissions or both CH_4 and CO_2 emissions. The Parties that reported under flaring in this section typically reported CO_2 emissions and lesser amounts of CH_4, and in most cases N_2O as well. Generally, it is expected that some venting or flaring would occur during oil or natural gas activities. Normally the vented emissions would be expected to be predominantly CH_4 except where raw CO_2 emissions occur (e.g., gas processing plants and hydrogen plants at petroleum refineries and upgraders). Flaring emissions would be expected to be predominantly CO_2 with a small amount of N_2O and some CH_4 due to incomplete combustion.

43. Some additional observations, based on reported data from some Annex I Parties and which may need further consideration, are listed below:

(a) Carbon dioxide emissions from flaring are reported, but not CH_4 or N_2O emissions. This implies an assumption of 100 per cent flaring efficiency, which would normally underestimate total associated GHGs because unburned CH_4 has a greater global warming potential than CO_2

(b) Carbon dioxide emissions from oil-related flaring are reported, but not CO_2, CH_4 and N_2O emissions from gas-related flaring

(c) Carbon dioxide emissions are reported only under venting.

5. Other

44. Three Parties (Croatia, New Zealand and Portugal) provided estimates of fugitive emissions under the "Other" subcategory. All three reported CO_2 emissions and New Zealand also reported CH_4 emissions. The sources of these emissions included geothermal energy production for Portugal and New Zealand and natural gas scrubbing for Croatia.

D. Consideration of the Intergovernmental Panel on Climate Change methodologies

45. The main methodological issues in estimating fugitive emissions from oil and natural gas systems are a lack of a well-defined tier 3 approach, a tier 2 approach for natural gas systems, specific guidance on calculating CO_2, CH_4 and N_2O emissions from flaring and waste-gas incineration activities, adequate guidance on evaluating GHG emissions from petroleum refining, heavy oil upgrading and petroleum products distribution, and a discussion of what contributions might reasonably occur under the "Other" category in the CRF.

46. The tier 1 emission factors provided in the 1996 IPCC Guidelines quantify only CH_4 emissions and not CO_2 or N_2O emissions. Revised tier 1 emission factors that quantify all three of these GHGs are provided in table 2.16 of the IPCC good practice guidance; however, these factors are based on data from Canada and the United States and do not necessarily apply to other regions. Also, revised factors for petroleum refining and upgrading are not included.

47. Furthermore, although some Parties have made considerable improvements in their reporting practices in recent years, there remains great uncertainty in many reported vented and flared volumes. The main sources of uncertainty are as follows:

(a) Few vent or flare systems are actually equipped with flow meters so values must usually be estimated if they are reported at all

(b) Requirements for reporting vented and flared volumes vary greatly between jurisdictions and are often loosely enforced

(c) Historically, industry practice and government regulations have not generally required any distinction between vented and flared volumes, so the values have usually been combined and reported as a single value, or the vented volumes, by default, are often declared as flared volumes. The actual split has a major impact on the total CO_2-equivalent emissions from these activities because unburned CH_4 contributes about 7.6 times more radiative forcing on a 100-year time horizon than does fully combusted CH_4.

1. Tier 1 methodology

48. Tier 1 is the simplest as well as the least reliable approach. It is a top-down method in which average production-based emission factors are applied to reported oil and gas production volumes. This method is intended for use by countries with limited oil and gas industries, and with limited resources to develop more reliable estimates.

49. The use of a tier 1 approach implies a reasonable correlation between production or throughput volumes and fugitive emission levels. This may be valid for systems with high venting and flaring emissions, but for well-controlled systems the dominant source of emissions will tend to be equipment leaks, which are generally independent of system throughput. Only in the case of very large systems would a weak relationship between throughput and equipment leaks be expected.

50. The ability to account for specific control measures will become more important as Parties strive to meet their emission reduction targets. A tier 1 approach only captures the impact of any changes in gross activity levels. A tier 2 or 3 approach must be used to capture the impact of vapour and waste-gas control measures.

51. Table 4 compares the results of an independent calculation of the maximum and minimum emissions for oil and gas using a tier 1 approach against the actual values reported by Annex I Parties for 2000. The calculated values were developed using 2000 oil and natural gas, import, export and apparent consumption statistics published by the EIA at <www.eia.doe.gov/pub/international/iea2001/table31.xls> for oil, and at <www.eia.doe.gov/pub/international/iea2001.xls> for natural gas.

Table 4. Fugitive CH_4 emissions from oil and natural gas for 2000 reported by Annex I Parties and independently calculated tier 1 values

	Data reported by Annex I Parties for 2000			Independent tier 1 estimated emissions	
Party	Method used	Emission factors used	Reported emissions (Gg)	Min emissions (Gg)	Max emissions (Gg)
Austria	C	CS	5.71	19.27	36.27
Belgium	C	C	42.50	37.45	71.32
Canada	CS	CS	1 822.25	489.54	1 065.79
Czech Republic	T3	CS	28.77	45.78	101.10
Denmark	D	D	11.85	17.27	36.26
Estonia			20.38	5.17	11.41
Finland	CS	CS	0.37	10.03	19.15
France	C	CS	91.23	97.07	185.34
Greece	T1	D	1.52	5.00	10.47
Hungary	D	D	187.70	101.32	225.37
Ireland	NA	NA	4.16	10.14	18.89
Italy	D,C	D,CS	262.49	177.13	333.80
Latvia			15.99	7.38	16.22
Luxembourg			2.11	1.79	3.31
Netherlands	IE		131.22	152.45	284.32
New Zealand	T1	CS,D	17.63	67.98	147.63
Norway	T1	D	24.54	44.23	118.20
Poland	CS	CS	205.72	136.12	303.39
Portugal	C,T2	C	6.74	5.47	10.81
Slovakia	T1	CS	34.96	35.42	78.25
Spain	T1	CS	27.45	39.97	77.39
Sweden	CS	CS	0.00	2.16	5.28
Switzerland			12.27	7.08	13.37
United Kingdom	T2	CS	393.73	287.53	561.76
United States	T2,T3	CS	6 581.74	2 181.88	4 725.29

C: CORINAIR, CS: country specific, D: IPCC default, NE: not estimated, IE: included elsewhere, NA: not applicable, NO: not occurring, T1: IPCC tier 1 methodology, T2: IPCC tier 2 methodology, T3: IPCC tier 3 methodology.

52. These statistics were converted from a volumetric basis to a net heating value basis for use in the tier 1 calculations. A net heating value of 34,157 MJ/m^3 was applied to crude oil volumes and a value of 33 MJ/m^3 was applied to the natural gas volumes. Gas transmission volumes were assumed to be the sum of domestic production and imports. Gas distribution volumes were assumed to equal apparent gas consumption. The gas consumption was arbitrarily assumed to be equally split between industrial and commercial/residential end users. The amount of crude oil tankered was arbitrarily assumed to equal total export volumes for all island, Middle East, African and South American countries; otherwise oil exports were assumed to occur by pipeline.

53. The results in table 4 show that most Parties' reported fugitive CH_4 emissions from oil and natural gas are either within or just outside the calculated tier 1 range. This finding provides some validation of the emission values reported by Parties and, where Parties have applied better than tier 1 approaches, verifies the reasonableness of the tier 1 default emission factors. Selecting higher tier approaches offers the potential for greater accuracy, subject to the quality and completeness of the correspondingly more detailed data required by these methods. For some countries in table 4 there are relatively big differences between the reported and calculated values. Although insufficient information was generally available to resolve these differences, they appear to be due to a combination of different emission factors and activity levels.

2. Tier 2 methodology

54. The tier 2 method applies only to oil and requires knowledge of the amount of associated gas production or the gas-to-oil (GOR) ratio, as well as the level of gas conservation or utilization and the extent of waste-gas flaring. All other associated gas is either vented or leaked to the atmosphere. The total amount of associated gas and solution gas produced with the oil is assessed, then control factors are applied to the results to account for conserved, reinjected and utilized volumes. The result is the amount of gas either flared or lost directly to the environment (whether through equipment leaks, evaporation losses or process venting). The flared, utilized and conserved volumes are determined from available production accounting data and engineering estimates. The reliability of this approach increases as the portion of the total gas conserved, utilized, or reinjected decreases. The total amount of associated gas may sometimes be determined directly from production accounting statistics, or calculated based on the amount of oil production and the estimated average GOR for the target oil fields.

55. Table 5 presents a comparison of the minimum and maximum aggregate CH_4 emissions that would be expected from oil exploration, production and related venting and flaring activities, and compares the results to the corresponding total reported by Annex Parties for 2000. The tier 2 estimates were calculated based on the following:

(a) Oil production statistics published by EIA for 2000 were used (www.eia.doe.gov/pub/international/iea2001/table31.xls)

(b) The average GOR for each Party with oil production was assumed to be 249 m^3/m^3. This is the average value for all conventional and heavy oil production in Canada. Typical GOR values for oil wells are summarized by type of oil in table 6

(c) The CH_4 content of the associated gas was taken to be 73 per cent on a volume basis

(d) Of the associated gas produced by each Party 95 per cent was assumed to be conserved or utilized, which is roughly consistent with the level of conservation in the more regulated jurisdictions in North America

(e) The presented tier 2 CH_4 lower emission limit was calculated by assuming that no waste-gas venting or leakage occurs and all waste-gas volumes are flared

(f) The upper tier 2 CH_4 emission limit was calculated by assuming that no flaring occurs and all waste associated gas is either leaked or vented to the atmosphere

(g) The efficiency of destruction of CH_4 in flares was assumed to be 98 per cent.

Table 5. Fugitive CH_4 emissions from oil for 2000 reported by Annex I Parties and independently calculated tier 2 values

	Data reported by Annex I Parties for 2000			Independent tier 2 estimated emissions	
Party	Method used	Emission factors used	Reported emissions (Gg)	Min emissions (Gg)	Max emissions (Gg)
Austria	C	CS	0.00	0.16	7.88
Belgium	C	C	0.00	0.09	4.30
Canada	CS	CS	685.84	19.63	981.52
Czech Republic	T3	CS	0.04	0.04	2.18
Denmark	D	D	0.00	2.63	131.36
Estonia			0.08	0.03	1.70
France	C	CS	0.16	0.57	28.28
Greece	T1	D	0.04	0.06	3.13
Hungary	D	D	4.29	0.30	15.03
Ireland	NA	NA	NO	0.01	0.36
Italy	D,C	D,CS	1.67	1.11	55.31
Netherlands	IE		IE	0.63	31.71
New Zealand	T1	CS/D	IE	0.33	16.54
Norway	T1	D	10.62	23.77	1 188.38
Poland	CS	CS	2.02	0.09	4.62
Portugal	C,T2	C	0.00	0.01	0.72
Slovakia	T1	CS	0.01	0.01	0.36
Spain	T1	CS	0.03	0.13	6.71
Sweden	CS	CS	NO	0.03	1.43
Switzerland			0.05	0.07	0.36
United Kingdom	T2	CS	55.98	18.23	913.86
United States	T2,T3	CS	977.05	64.85	3 242.57

C: CORINAIR, CS: country specific, D: IPCC default, IE: included elsewhere, NA: not applicable, NO: not occurring, T1: IPCC tier 1 methodology, T2: IPCC tier 2 methodology, T3: IPCC tier 3 methodology.

Table 6. Typical ranges of gas-to-oil (GOR) ratios for different types of production[a]

Type of crude oil production	Typical GOR range (m^3/m^3)
Conventional oil	200 to 2 000+ [b]
Primary heavy oil	0 to 325+ [c]
Thermal heavy oil	0 to 90
Crude bitumen	0 to 20

[a] Based on unpublished data for a selection of wells in North America.
[b] Appreciably higher GOR values may occur, but either these wells are normally classified as gas wells or there is a large gas cap present and the gas would be reinjected until all the recoverable oil had been produced.
[c] Values as high as 7,160 m^3/m^3 have been observed for some wells where there is a large gas cap present. Gas reinjection is not done in these applications – the gas is conserved or vented or flared.

56. The results in table 5 show that, for most Annex I Parties, the aggregate reported fugitive CH_4 emissions from oil exploration, production and related venting and flaring are either within or just outside the calculated tier 2 range. It is interesting to note that in most of these cases the reported values are much closer to the lower than the upper limit of the calculated tier 2 emission range. Considering the assumptions used in these calculations, the tier 2 limits probably understate the true range. Also, considering that typical practice is to vent rather than flare waste-gas volumes unless the gas contains H_2S or it is offshore production, it would be expected that CH_4 emissions reported by most Parties for oil would be well above the lower tier 2 values.

3. Tier 3 methodology

57. The tier 3 approach includes a rigorous assessment of emissions from individual sources using a bottom-up approach, and requires both information on process infrastructure data (i.e., on the amount and type of equipment used) and detailed production accounting data. It may also include actual emission measurement results. The results are then aggregated to determine the total emissions for the sector.

58. Much of the oil and gas industry tends to be characterized more by many small facilities than by a few large ones, making the application of a tier 3 approach more difficult. The performance of a rigorous bottom-up assessment of emissions requires detailed information on production, venting, flaring, control measures, operating practices and amounts and type of process equipment. Often much of this information is either unavailable or costly and time-consuming to compile. There are no clear guidelines on the minimum required data quality needed to achieve more accurate results compared to lower tier approaches; however, the typical uncertainties of the input emission factors and activity data for all key subcategories would generally need to comparable to or better than the uncertainties of the emission factors and activity data used in the lower tiers.

4. Activity data

59. In the absence of national statistics for the estimation of emissions from oil and natural gas, national GHG inventory experts resort to the use of internationally published data. However, the appropriateness of such information for the purpose of a GHG inventory compilation depends on the underlying assumptions associated with these data. For example:

(a) Gas production data reported by international sources are expressed on a net basis (i.e. after shrinkage, losses, and re-injected, vented and flared volumes). When data are expressed on an energy basis, United Nations Statistics Division and IEA apply the net calorific values, whereas EIA uses the gross calorific value (the convention varies between national reporting agencies). Natural gas includes gas originating from gas wells, conserved gas produced in association with crude oil, and methane recovered from coal mines (colliery gas);

(b) Some venting and flaring statistics do not differentiate between acid-gas flaring and other waste-gas flaring. Acid-gas streams are a by-product of the sweetening process at sour-gas processing plants and refineries, and may contain large amounts of raw CO_2 extracted from the process gas (typically, from 20 to 95 mole per cent CO_2). The rest of the acid gas tends to be mostly H_2S. The amount of acid-gas production is usually metered; although not typically tracked by regulatory agencies, the CO_2 content is known by the facility operators. Depending on the raw CO_2 content, the net emissions of CO_2 per unit volume of acid gas flared may be appreciably less than for typical waste-gas streams. If the acid gas is processed by a sulphur recovery unit rather than being flared, the raw CO_2 passes through the process and is discharged through the final tail gas incinerator, and is not reported in the available statistics as either vented or flared gas.

60. The 1996 IPCC Guidelines and the IPCC good practice guidance do not provide guidance for national GHG inventory experts on how to handle international statistical information to ensure that emissions from oil and natural gas are estimated accurately.

E. Alternative calculation schemes

61. Several substantial advances have occurred in recent years in the development of improved emission factors and methodologies for conducting source-specific assessments of oil and natural gas

fugitive emission. In 2003, the International Petroleum Industry Environmental Conservation Association (IPIECA), in collaboration with the American Petroleum Institute (API) and the International Association of Oil and Gas Producers (OGP), initiated the development of *Petroleum Industry Guidelines for Reporting Greenhouse Gas Emissions*.[7]

62. These guidelines were developed by a Joint Industry Task Force consisting of member company experts from BP, ChevronTexaco, ExxonMobil and Shell. The guidelines delineate petroleum industry GHG accounting and reporting principles and inventory assurance processes, and provide guidance for establishing organizational and operational boundaries, evaluation of industry GHG emissions, evaluation and reporting of GHG emissions.

63. Protocols for estimating GHG emissions have also been developed by a number of national oil and gas industry associations. These documents have all typically featured detailed compendiums of emission factors and tiered source-specific calculation procedures, and may be useful supplemental references for use by Parties. A recent compendium of many of these methodologies and associated emission factors has been published by API.[8]

64. The calculation methodologies in the API compendium are consistent with the emission source categories used in the *Petroleum Industry Guidelines for Reporting Greenhouse Gas Emissions*. API is working with the United States Department of Energy and international industry groups to ensure its widest possible use. Although the compendium is a useful tool, some noteworthy limitations of the document with respect to developing national estimates of fugitive GHG emissions from oil and gas systems include the following:

(a) The source classification scheme is not consistent with that of the 1996 IPCC Guidelines and the IPCC good practice guidance. The IPCC methodology divides emissions from oil and gas systems into two main categories: emissions from fuel combustion and fugitives (i.e., emissions from all other sources including venting, flaring, equipment leaks and accidental releases). The API divides emission sources into three categories: combustion (fuel and waste gas), venting and fugitives (equipment leaks and other sources). These classification differences pose a reporting issue rather than a technical or methodological issue

(b) The API compendium is designed primarily for use by oil and gas companies in developing facility and company level emission estimates, rather than for developing a national inventory of fugitive emissions from oil and gas systems

(c) In general, the API compendium requires detailed activity data (e.g., numbers of facilities and installations, numbers and types of major equipment/process units at each site, and corresponding production accounting data and, in some cases, gas analyses). Many of these data would be difficult to obtain, even for individual oil and gas companies, and no guidance is provided for compiling or, where appropriate, for estimating this information

(d) IPCC practice is to account for all releases of carbon to the atmosphere as CO_2 except unoxidized carbon in the form of particulate matter, soot or ash. Carbon released as carbon monoxide (CO), methane, or non-methane volatile organic compounds (NMVOCs) is to be evaluated separately from, and in addition to, the CO_2 emission assessment. This allows for the fact that these non-CO_2 compounds all oxidize to CO_2 in the atmosphere within a period of a few days to about 12 years. The API compendium

[7] http://www.ipieca.org/downloads/climate_change/GHG_Reporting_Guidelines.pdf
[8] http://api-ec.api.org/policy/index.cfm

complies with this requirement for fuel combustion but does not account for the atmospheric oxidation contributions from flaring, venting and other fugitive sources

(e) Regional and national differences in default emission factors are not provided. Most factors are based largely on data from North America and may not reflect conditions in other regions

(f) Not all potential segments of oil and gas systems are addressed. For example, oil sands mining, extraction and upgrading, and shale oil production are excluded

(g) The matter of formation CO_2 emissions is not well addressed. Users of the API compendium are expected to provide detailed estimates of formation CO_2 releases at individual facilities. No default emission factors for estimating these emissions are provided.

V. Conclusions

A. General

65. The tier 1 approaches for solid fuels, oil and natural gas do not allow Parties to show any real changes in emission intensities over time (e.g., due to the implementation of control measures or changing source characteristics). Rather, emissions become fixed in proportion to the activity levels, and the changes in reported emissions over time simply reflect the changes in activity levels. Tier 2 and 3 approaches are needed to capture real changes in emission intensities. However, going to higher tier approaches requires more detailed activity data and effort, and the completeness and accuracy of the input information will generally need to be comparable to, or better than, the values of the input information used for the lower methodological tiers in order to achieve more accurate results.

B. Solid fuels

66. For solid fuels, the methodological approaches and emission factors presented in the 1996 IPCC Guidelines and the IPCC good practice guidance provide a good basis for the evaluation of fugitive CH_4 emissions from coal mining and post-mining activities. However, there is scope for improvement, particularly in the following areas:

(a) Development of specific procedures for solid fuels other than coal (e.g. peat preparation and coke production)

(b) Guidance on how to evaluate emissions from post-mining activities. In particular, it is not clear how the emissions from post-mining activities should be allocated for imported and exported coal volumes because some of the post-mining emissions for this coal will occur in both the exporting and importing countries

(c) Guidance on how to estimate emissions from abandoned or closed mines

(d) Specific guidance for evaluating CO_2 and N_2O emissions from the flaring of gas from mine degassing wells or catalytic oxidation of exhaust air from underground mines

(e) Guidance on how internationally published statistical information should be handled for the purposes of the GHG inventory compilation.

C. Oil and natural gas

67. Based on the application of a tier 2 calculation approach and some conservative assumptions about the level of associated gas conservation, it appears that the methodologies and assumptions being

applied by some Annex I Parties to estimate CH_4 emissions from oil exploration, production, and related venting and flaring activities may lead to the underestimation of actual emissions. This is largely attributed to the generally poor quality of available venting and flaring data. However, for the purpose of this note, a trend assessment was not carried out, so it is not possible to determine whether these methodologies and assumptions would have an adverse impact on the time series calculation.

68. Improvements to the methodological approaches and emission factors for estimating fugitive emissions from oil and natural gas systems are needed. For example:

(a) Better methodological guidance is required to help Parties determine which oil and gas subcategories apply to their systems and what GHGs may occur

(b) The IPCC good practice guidance does not contain specific guidance on the use of estimates reported by individual oil and gas companies. Specific concerns are completeness, transparency, uncertainty analysis, potential for missing activities and double counting, and time series consistency

(c) Default emission factors are needed to assess fugitive CO_2 emissions by subcategory for all geographic areas. For N_2O, it is suggested to assess the level of emissions for this gas and then, based on this assessment, to consider the possibility of developing a tier 1 methodology

(d) A tier 2 approach needs to be developed for natural gas systems

(e) Better delineation of the tier 3 approach is needed, including the provision of source-specific emission calculation procedures and corresponding emission factors

(f) There is a need for guidance and factors for estimating contributions due to atmospheric oxidation of non-CO_2 gaseous carbon emissions

(g) Guidance is needed for collecting, and where appropriate estimating, the activity data required by tier 2 and 3 approaches, and on how internationally published statistical information should be handled for the purposes of the GHG inventory compilation

(h) Tests are needed for evaluating the reasonableness and completeness of results.

69. In addition to the above, the IPCC could consider whether the *Petroleum Industry Guidelines for Reporting Greenhouse Gas Emissions* and the API compendium provide useful information (methodologies and/or emission factors) that could be used during the development of the 2006 IPCC Guidelines.

70. Finally, gas removed from the process for on-site or field uses is notionally referred to, and reported as, fuel gas. However, some of this gas may be used for purposes other than fuel combustion such as blanket gas, flare and vent header purge gas, instrument supply gas, enriching of acid-gas streams to allow stable flaring, blowcase gas, and compressor start gas. It is believed that such activities account for a rather small amount of emissions. The IPCC could consider whether additional guidance is needed to properly account for these other uses.

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